UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

RED KIDNEY BEANS IN CALIFORNIA

FRANCIS L. SMITH

BULLETIN 669
August, 1942

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

CONTENTS

RED KIDNEY BEANS IN CALIFORNIA[1,2]

FRANCIS L. SMITH[3]

THE RED KIDNEY BEAN has been grown commercially in California for many years. Along with the other common beans this is a variety of *Phaseolus vulgaris*. The exact date of its introduction is not known (*9*)[4], but eastern seed catalogs listed it as early as 1857 (*8*). Since it is an old variety, there are now several selections with different characteristics. Judging from different types of Red Kidney—Wells, York, and Geneva (*10*), the California variety resembles Wells more closely than it does the other two. Wells originated from a selection made by Byron Bruce at Marion, New York, about 1904 and later distributed and named by John Q. Wells of Shortsville, New York (*8*).

RED KIDNEY BEAN PRODUCTION AREAS IN CALIFORNIA

California, producing about 12 per cent of the nation's Red Kidney beans, ranks a poor third to New York with 52 per cent of the national total, and Michigan with 33 per cent (*6, 7, 11, 13*). Table 1 gives the production for the years 1934–1941 for different areas in the state, together with the total for California, New York, Michigan, and the United States.

California has steadily increased its production of Red Kidney beans from 61,000 (100-pound) bags in 1934 to 180,000 in 1941. Obviously, then, this variety is expanding in acreage and may continue to do so.

For convenience the agricultural statisticians have divided the state into eight areas, four of which produce Red Kidney beans: the Sacramento Valley, the San Joaquin Valley, the coast counties, and southern California. The latter two areas have been less important than the valley districts. The coast counties produce annually 5,000 to 11,400 bags, or an average of 6.0 per cent of the state's total. Southern California has produced 4,100 to 10,000 bags, or an average of 8.5 per cent of the state's production in the past eight years. Production there has now decreased slightly, whereas there was a sharp increase in the coastal district in 1941.

Between 1934 and 1940 the Sacramento Valley produced 27,000 to 39,100 bags annually. In 1941 the production almost doubled to 53,600 bags.

[1] Received for publication April 13, 1942.

[2] Assistance in the breeding work reported herein was furnished by the personnel of Work Projects Administration, Official Project No. 265–1–08–80, Unit B–4.

[3] Assistant Agronomist in the Experiment Station.

[4] Italic numbers in parentheses refer to "Literature Cited" at the end of the bulletin.

In the San Joaquin Valley the figure for 1941 was over five times that for 1934. By 1936 this area surpassed the Sacramento Valley in production and has maintained the lead. By 1941 San Joaquin was producing over 60 per cent of the total for the state. This area may easily continue to maintain its dominance.

TABLE 1

PRODUCTION OF RED KIDNEY BEANS IN CALIFORNIA BY DISTRICTS, AND IN NEW YORK, MICHIGAN, AND THE UNITED STATES

Area	Production in thousands of bags*							
	1934	1935	1936	1937	1938	1939	1940	1941
Sacramento Valley	27.0	30.0	31.5	36.9	39.1	19.1	29.7	53.6
San Joaquin Valley	19.0	26.0	33.5	47.7	42.2	32.7	64.4	110.6
Coast counties	5.0	5.0	5.5	8.2	6.0	3.1	4.1	11.4
Southern California	10.0	10 0	5.5	6.2	7.7	4.1	4.8	4.4
Total for California	61.0	71.0	76.0	99.0	95.0	59.0	103.0	180.0
New York	327.0	381.0	413.0	453.0	565.0	431.0	373.0	760.0
Michigan	153.0	167.0	167.0	225.0	242.0	257.0	191.0	194.0
Total for United States	563.0	631.0	675.0	793.0	923.0	762.0	683.0	1,164.0

* Bags of 100 pounds.

The increased production is not limited to California. New York production for 1941 was over 2⅓ times that of 1934, and the national total was doubled.

Within the four general areas in California the Red Kidney bean is further restricted. In the Sacramento Valley this variety has done best in the bottom lands of the Feather, Yuba, and Sacramento rivers. The main crop is grown in Yuba and Sutter counties, with limited production around Vina in Tehama County. In the San Joaquin Valley, Red Kidneys are grown in the river-bottom lands rather than in the open valley and are limited largely to San Joaquin County. The Red Kidney beans from the coastal areas are grown largely near Watsonville and Salinas.

THE SEED-BEAN TRADE

The Red Kidney beans of California are largely sold as dry beans (*14*), very few being canned or exported.

An interesting specialized industry developed in the last few years has been the production of certified disease-free seed for growers of Red Kidney beans in New York state (*7*). Although at present it uses only a small fraction of the total California crop, this industry has received much attention from the University of California College of Agriculture. A discussion, therefore, of its development seems appropriate.

Because of the rainless season during the growing period in California two serious bean diseases common in the East do not occur in this state even though Red Kidney is susceptible to both. One is a fungus disease, anthracnose, caused by *Colletotrichum lindemuthianum*. The other is really several bacterial diseases, as described by Burkholder (*5*). These are the blight caused by *Phytomonas phaseoli,* the wilt caused by *Phytomonas flaccumfaciens,* and the halo blight caused by *Phytomonas medicaginis* var. *phaseolicola.* In addition Burkholder found the following pathogens destructive to the bean crop: *Phytomonas phaseoli* var. *fuscans, Phytomonas vignae* var. *leguminophila,* and *Phytomonas viridiflava.* These diseases, collectively known as bacterial blight, sometimes cause considerable damage in New York, Michigan, and other eastern as well as western states. Young (*15*) calculated the loss in yield of Wells Red Kidney at 89 per cent in 1927 for two important bean-producing counties in New York. As a preventive he recommended the use of blight-free California seed grown in the Sacramento Valley.

California's position in disease-free seed production is very fortunate. The weather conditions, being unfavorable for the disease-producing organisms, have been far more important than the care taken to exclude the diseases. The bacteria are borne in the seed of infected plants and can begin a new infestation under favorable conditions. Eastern-grown seed has undoubtedly been planted here on numerous occasions, and no doubt the disease would be established now if the weather conditions had favored the growth of the bacteria. In 1939 the writer saw some fields of White Kidney planted from seed obtained from New York. Certain seedlings were diseased and soon died. From these, *Phytomonas* bacteria were isolated in the laboratory. The remaining plants, however, continued to grow, and no effects of blight were apparent 10 days later except a poor stand.

For many years California Red Kidney beans, especially those grown near Marysville, enjoyed a reputation of being blight-free when planted in New York. In the latter part of the twenties, however, there were persistent complaints in New York about the poor quality of California beans. The California beans carried mixtures of other varieties, small beans, broken beans, bean straw, and other adulterations. This led many buyers to object because in New York seed beans are hand-picked. The seed was also reported to be infected with bacterial blight.

Up to that time the interstate trade had been handled by brokers and dealers of dry beans. Since the seed was handled merely as commercial beans, no legal requirements for seed in interstate commerce could be enforced. In the absence of any restraint by law, commercial practices were indulged in, such as blending of lots from different localities. Blend-

ing, though satisfactory in the dry-bean trade, is disastrous for seed, especially when beans from a disease-free area are mixed with beans from regions infested with blight.

By 1930 the California product was in such bad repute that New York growers were seeking other sources for their blight-free seed. Realizing the gravity of the situation, M. D. Collins, Farm Advisor of Yuba County, began working to reëstablish a business of mutual benefit to Red Kidney bean growers on two sides of the continent. Although results as reported here emphasize the crop-improvement program, the author realizes that this work is only part of the many-sided problem of establishing and maintaining an industry.

In 1930, at the request of Mr. Collins, a number of Red Kidney bean fields were surveyed in Yuba County. They contained a high percentage of viny and off-color types. Not all these forms were mechanical mixtures with other varieties; a number, grown in progeny rows in 1931, were found to be hybrids. The fields also had a high percentage of bean mosaic. Two selected fields were carefully rogued of all viny and diseased plants. The seed used to plant one of these fields was reputed to be the increase from Wells Red Kidney beans obtained from New York a few years earlier. Seed from this field was used as a foundation of "Simpson's Strain." The seed used to plant the other field was of undetermined origin and was propagated as "Kupser's Strain." After being grown for two years, it was abandoned in favor of Simpson's, which has maintained its identity for a decade.

In 1931 and 1932 a tag was put inside each sack of beans shipped east, giving the grower's name and address and other information. That some of this seed reached New York is evident from letters received by California growers. The method of identification was not satisfactory, however, because it did not prevent the seed from being blended with infected seed between the time it left California and reached New York; several such cases were detected. To protect the identity of the seed, some certification seemed necessary. There is an impartial agency, founded by several coöperating state and farm organizations, and known as the California Approved Seed Plan. The product thus certified is called Calapproved seed. It meets all legal requirements for certified seed in other states. The plan is sponsored primarily by the California State Seed Laboratory and the College of Agriculture. An executive secretary looks after the certification, and enforces the rules of procedure established for each crop. For Red Kidney beans the grower must apply for Calapproved seed before planting; further, he must plant it on land free from volunteer bean plants of other varieties. He pays 20 cents per acre for inspection service, tags, and seals. The crop receives inspection

twice during the season by a trained plant pathologist; once three weeks after planting and again during the blooming stage. The field must show less than 0.2 per cent of mosaic in the first inspection, less than 2 per cent in the second, and must contain less than 0.1 per cent of other varieties. The beans must be threshed by a clean machine and sacked in bags stenciled with the grower's number. After harvesting, official samples of the seed must show less than 0.1 per cent foreign seed, less than 4 per cent inert matter and defective seed, and must germinate 85 per cent. Seed that fails in any particular is immediately refused approval. Satisfactory seed is sacked in 100-pound bags bearing the stencil number, labeled with a certification tag, and sealed with a patented metal seal.

In 1933 one carload containing 400 bags of Calapproved Red Kidney bean seed was shipped directly from a Marysville grower to New York, where it made a favorable impression. Special precautions were taken to insure the purity by sealing each bag and the seals were on at the time of delivery. The Calapproved method of handling seed has gradually gained the confidence of eastern growers. In 1934 and 1935, other carloads, each comprising 600 sealed bags of 100 pounds each, were marketed in the same way. The annual shipments of Red Kidney bean seed were 8 carloads in 1936, 8 in 1937, 20 in 1938, 12 in 1939, 20 in 1940, and 34 in 1941.

Interested growers in Marysville formed a nonprofit coöperative in 1939. The organization markets the beans but is not responsible for seed certification, which is still handled under the California Seed Plan. A similar coöperative was started in the San Joaquin Valley in 1940.

As table 2 shows, the acreage of Red Kidney beans under Calapproval has increased from 250 in 1932 to 1,812 in 1941.

The yields in New York have been estimated at 8.0 to 8.5 (100-pound) bags per acre (*7*). The 1941 crop of 760,000 bags was produced on an estimated 89,000 to 95,000 acres. Planting at 60 pounds per acre, 53,500 to 57,000 bags of seed would be required. The production of Calapproved seed in 1941 was 24,117 bags, or only 42 to 45 per cent of the amount needed to plant a similar crop in New York. This 1941 California crop was considerably above the average. For a 500,000-bag crop, New York would require 35,300 to 37,500 bags of seed, whereas the present California production is enough for about two thirds that amount. Estimating the production at 12 bags per acre, California will need about 9,000 bags of seed to produce 180,000 bags for local use. In the future it is also possible that demand for this disease-free seed will develop in Michigan and other states. Obviously, then, the Calapproved seed industry has room for expansion.

TABLE 2

ACREAGE AND PRODUCTION OF CALAPPROVED CERTIFIED SEED OF RED KIDNEY BEANS BY COUNTIES AND YEARS

County	1932	1933	1934	1935		1936		1937		1938		1939		1940		1941		
	Acres	Acres	Acres	Acres	Bags	Acres	Bags	Acres	Bags	Acres	Bags	Acres	Bags	Acres	Bags	Acres	Bags	Index*
Yuba	250	332	325	179	2,065	431	3,957	432	5,161	755	9,186	625	6,163	715	9,202	655	7,799	48.8
Sutter	...	...	68	37	406	82	744	84	889	464	4,561	37	532	79	1,271	238	2,839	46.5
Butte	...	...	...	...	.....	...	.....	...	.....	12	130	...	.....	...	.....	25	127	54.0
San Joaquin	...	...	...	...	.....	...	.....	...	.....	70	1,448	100	1,694	190	3,077	698	11,777	49.9
Tehama	...	...	...	...	.....	...	.....	...	.....	266	3,632	...	.....	...	.....	...	.....	....
Monterey	...	...	...	...	.....	...	.....	...	.....	...	.....	...	.....	10	125	56	520	49.8
Yolo	...	...	...	...	.....	...	.....	...	.....	...	.....	...	.....	...	.....	140	1,055	42.7
State total	250	332	393	216	2,471	513	4,701	516	6,050	1,567	18,957	762	8,389	994	13,675	1,812	24.117	48.8

* Index is the average weight of 100 beans in grams.

TABLE 3

RESULTS OF TESTS OF SOME RED KIDNEY SELECTIONS AT MARYSVILLE, 1936–1940

Variety	Accession no.	1936			1937			1938			1939			1940			Average		
		Replications	Index*	Pounds per acre	Replications	Index*	Pounds per acre	Replications	Index*	Pounds per acre	Replications	Index*	Pounds per acre	Replications	Index*	Pounds per acre	Years	Index*	Pounds per acre
Red Kidney	7811	4	49.8	2,793	6	53.4	2,617	8	55.9	2,569	7	48.7	1,880	16	56.0	2,364	5	52.8	2,445
Red Kidney	7812	4	56.6	2,605	6	63.1	2,777	8	61.0	2,496	7	52.8	1,917	..	....	.....	4	58.4	2,449
Maui Red Kidney	7815	4	52.1	2,865	6	56.2	2,897	8	54.5	2,506	7	54.4	2,206	..	....	.....	4	54.3	2,619
Michigan Dark Red Kidney	8099	..	....	.....	..	....	.....	8	56.9	2,331	7	53.7	1,929	5	59.4	1,404	3	56.7	1,888
Red Kidney	7803	3	45.8	2,683	6	49.3	2,412	8	46.9	2,355	7	47.4	1,976	..	....	.....	4	47.4	2,357
Geneva Red Kidney	7795	3	44.3	2,360	6	50.8	2,772	8	47.5	2,178	..	....	.....	..	....	.....	3	47.5	2,437
Red Kidney	7799	3	44.9	2,727	6	49.5	2,757	8	48.1	2,545	7	46.9	1,930	..	....	.....	4	47.4	2,490
York Red Kidney	7796	2	44.6	2,350	6	56.2	2,155	..	....	.....	..	....	.....	..	....	.....	2	50.4	2,253
Red Kidney (check)	....	10	44.2	2,417	10	50.1	2,390	8	49.7	2,270	7	45.8	1,916	..	....	.....	4	47.5	2,248

* Index is the average weight of 100 beans in grams.

CULTURAL PRACTICES

The areas of California suitable for Red Kidney beans have already been discussed.

Seed.—Calapproved seed is recommended for efficient production. Having been produced under ideal conditions, it will give more reliable performance than other seed. It has successfully passed rigid tests for purity and freedom from disease, and has been tested for germination.

Planting Time.—In the Sacramento and San Joaquin valleys the beans should be planted between June 20 and July 10. If sown earlier, the plants will bloom in early August during severely hot dry weather, which causes the blossoms to drop off. Postponement of planting till the June 20 to July 10 period also prevents losses from wireworms, which recede into the soil as the top soil layer becomes heated. It minimizes trouble with rhizoctonia stem rot (*Corticium vagum*) and other organisms that cause damping-off; also injury from red-spider infestation. Usually, too, it results in larger beans. Planting later in July increases the hazards from fall rains; this increases the harvesting costs and impairs the quality. Seeding in the coastal and southern areas may be made earlier than June 20.

Beans are planted with two-, four-, or eight-row planters, using planter plates to fit the size of the seed. The row width is usually 28 to 30 inches. If rows are spaced wider than 30 inches the soil is not completely utilized.

Planting Rate.—The rate of planting depends on size of seed, width of row, and spacing within the row. Assuming 4-inch spacing in 28-inch rows, 56,000 seeds are required to plant an acre. The rate of planting would then be determined by seed size, which can be measured as the number of seeds per ounce or per pound or as the weight of a given number. The weight method is used for investigations in California. For seed-size determination 100 beans taken from a sample are weighed in grams. This weight is the "index," from which one can easily calculate the number of seeds per ounce. Table 2 gives, by counties, the indexes of the Calapproved beans grown in 1941. These were obtained by taking the index of a sample from each grower and multiplying it by the number of bags produced; the sum of the products was then divided by the number of bags produced by the county. In 1941 the county indexes varied from 42.7 to 54.0, and the indexes on the samples varied from 37.8 to 55.2, or 824 to 1,200 beans per pound. To plant an acre, 60 pounds of seed would be required with an index of 48.8—the state average of Calapproved beans in 1941. With small seed having an index of 40, the planting rate would be 51 pounds per acre, and using

large seed with an index of 55, the rate of planting would be 71 pounds per acre. The average planting rate used by commercial growers is about 60 pounds per acre, ranging from 50 to 70 pounds.

Water.—Many acres of Red Kidney beans in Yuba County are grown on acres flooded by the Feather River during the winter and spring and are not otherwise irrigated. Beans grown under irrigation are usually watered by the furrow method. Other methods of applying water are: flooding between ridges 20 to 25 feet apart, sprinkling with an overhead removable sprinkling or rain machine, and subirrigation, wherein the height of the water table can be regulated by water in spaced subirrigation ditches.

Besides keeping the plants growing thriftily, abundant moisture repels the red spider, which may become serious on plants suffering for water. Irrigation can be overdone, however, especially after blooming. If the plants are large enough to cover the soil surface completely, conditions are ideal for rapid growth of the cottony mold fungus (*Sclerotinia sclerotiorum*), which parasitizes the plants and kills them prematurely. Control of this disease is best accomplished by keeping the soil surface around the plants dry in the latter stages of growth.

Cultivation.—Cultivation is intended mainly to keep down weed growth. Besides competing for water and nutrients, some weeds are harmful in other ways. The ground cherry (*Physalis pubescens*), for example, stains the beans in threshing and delays drying of the beans. The fruits of this weed, in threshed beans, are crushed in handling; and, being green, they dampen the beans which come into contact with them. The areas on the seed coat swell and later dry out. The expanded seed coat, however, does not shrink but forms folds and wrinkles on the areas affected. This condition is often interpreted as rain damage.

Harvesting.—Red Kidney beans lose their foliage while ripening. To preserve the seed color the plants should be harvested before too many leaves are lost, for leaves protect the pods from the sun. Red Kidney beans turn brown when subjected to sunshine for any extended period. Sunburning detracts from the appearance of the seed. The beans are ready to cut when they begin to show red color on the seed coat.

Beans are harvested with two- or four-row bean cutters, whose blades cut through the soil an inch or two under the surface. After cutting, the beans are piled in windrows to cure, four to six rows per windrow. They are threshed with machines having pickup arrangements that feed the plants through in a continuous ribbon as the machine is moved along the windrow (fig. 2).

Since emphasis is on seed production, more attention is being paid to thresher damage. The Agricultural Engineering staff of the University

made a study of bean threshers and found that the cylinder-type thresher could not be run slowly enough to eliminate the damage (*1*). They designed a thresher model (*2, 3*) in which the beans were removed from the pods by going between three sets of rubber rolls. This device re-

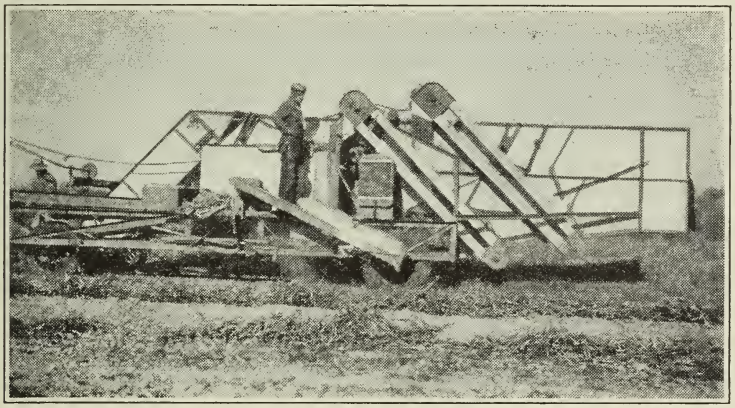

Fig. 1.—Rubber-roller threshing machine at work. There are two windrows of unthreshed beans in the foreground.

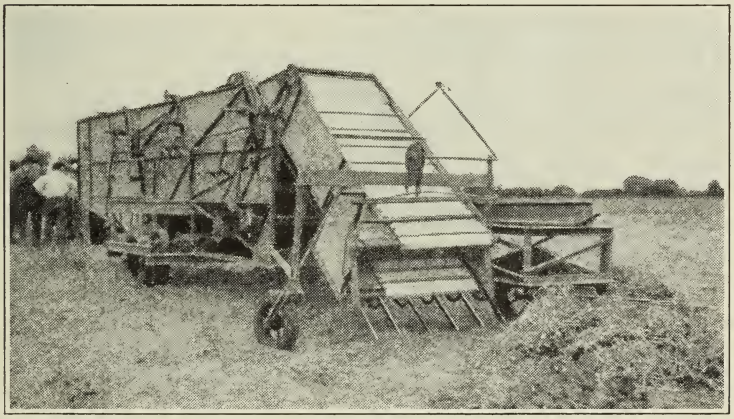

Fig. 2.—Front view of rubber-roller threshing machine, showing the pickup arrangement.

duced cracking to almost nothing. Several similar commercial machines have been made by a harvester company, and one has been used in the Marysville district for three years. In these machines the beans pass between two sets of rubber rolls, the third set being a cylinder that takes out the few beans left in the pods. It also tears up the straw so that the latter is more evenly scattered on the ground. Figures 1 and 2 give different views of a commercial rubber-roller threshing machine.

Thresher Damage.—Thresher damage is serious when beans are used for seed. In interstate commerce, soundness is even more important because the shipper must state the germination percentage on the tag. Rough handling is evidenced by cracked and broken beans. If the injured beans could be removed by hand-picking, the problem would be fairly simple. But much of the injury cannot be discovered until the beans are germinated. The damage then appears as a high percentage of beans with damaged embryos or "baldheads" (*4*), which are not counted as germinated beans in official tests. Every year, part of the crop is rejected because of low germination. Figure 3, *F*, shows the bean cotyledon and the young embryo, which is located so near the end of the bean as to be highly vulnerable to mechanical injury.

Figure 3, *A* to *E*, shows several types of seed injury. The photograph was taken in the State Seed Laboratory from a sample submitted for test. The three beans on the left were so badly damaged that they would not emerge in the field. A typical "baldhead" is shown at *D*. Only the plumule is injured but it fails to expand. Such seedlings are not counted as germinated in official tests because most of them will die and those which survive would have to put out new leaves from the growing point and would be considerably later and weaker than the normal seedling, shown in figure 3, *E*.

The rubber-roller thresher is the most effective device for preventing thresher injury.

Recleaning Beans.—While on the subject of seed damage we may well emphasize the injury arising from recleaning. Beans taken from the field run often have a higher germination than the samples of the same seed after recleaning. This recleaning injury is clearly shown even when thresher damage has been almost entirely eliminated by rubber rollers (*3*). In the future more emphasis must be laid on reducing the recleaning damage in warehouses preparing bean seed for market.

Diseases and Pests.[5]—Rotting of seed is caused by various organisms that attack and kill the seedlings emerging from the soil. The result is poor stands. If Red Kidney beans are planted at the proper time, much of this damage, associated with cold, wet soil, is eliminated.

Cottony rot is caused by the fungus *Sclerotinia sclerotiorum*. It may be serious on Red Kidney beans if they are irrigated late and if the growth is so rank that the ground does not dry around the plants. The most effective way of avoiding the disease is to keep the soil surface dry

[5] More detailed discussion of diseases and insects affecting beans may be found in the following publications:

Essig, E. O., and W. M. Hoskins. Insects and other pests attacking agricultural crops. California Agr. Ext. Cir. 87:1–155. 1934.

Smith, Ralph E. Diseases of truck crops. California Agr. Ext. Cir. 119:1–112. 1940.

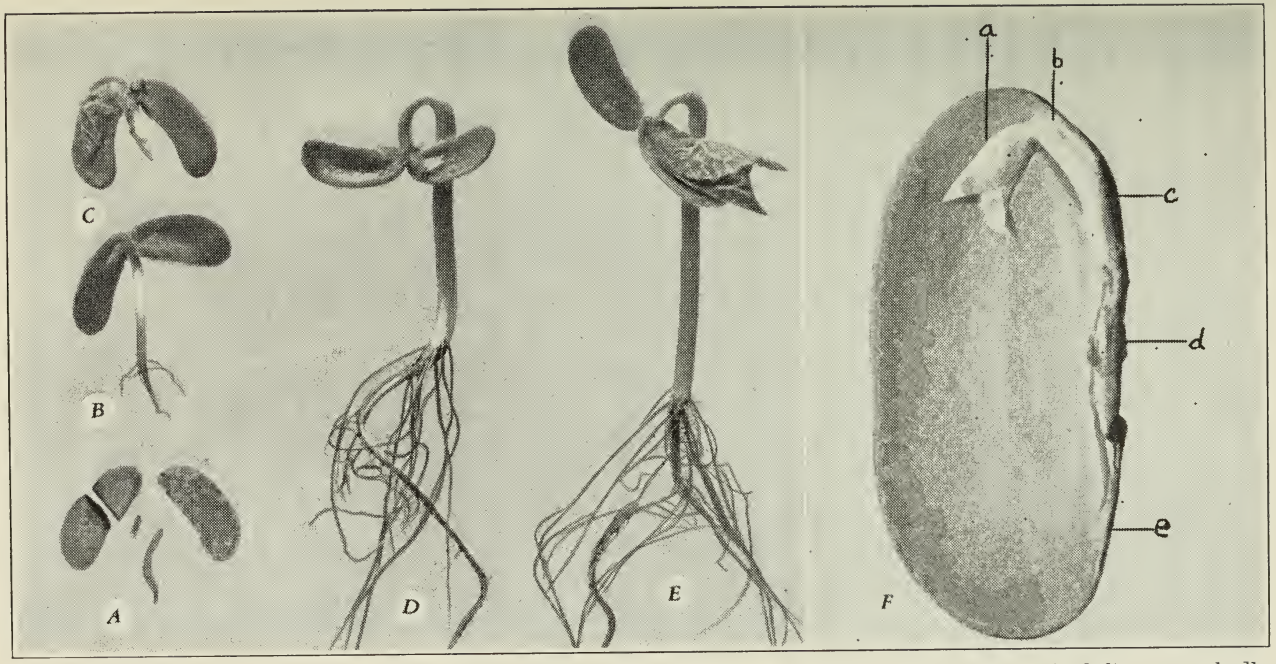

Fig. 3.—Red Kidney beans after germination test of 6 days are shown in *A–E*. The three seeds at the left were so badly damaged that they would not emerge in the field. *A*, Cotyledon fractured and both radicle and plumule injured. *B*, Cotyledon not broken but both plumule and radicle are injured. *C*, Radicle broken but plumule normal. At *D* is shown a typical "bald-head;" the cotyledons are intact, the root development is normal, but the plumule was injured and is dead. *E*, Normal germinating seedling. *F*, Split bean showing one cotyledon with the young embryo. The embryo, *a–c*, is located very near the surface at one end of the seed and is thus susceptible to injury by rough handling. The parts of the embryo are *a*, the plumule which develops into the cotyledon leaves; *b*, the hypocotyl from which the stem develops; and *c*, the radicle from which the root system develops. The hilum of the seed is shown at *d*, and the seed coat at *e*. (Photograph by F. G. Parsons.)

during the latter part of the season. To accomplish this, lighter rates of planting may be necessary in rich soil. After the pods are formed, irrigations should be avoided where the plant growth is sufficient to shade all the surface.

Of the numerous legume virus diseases, the bean virus causing mosaic is the main one affecting Red Kidney. Since primary infection is through the seed, the infected plants must be kept to a minimum to reduce transmission the following season. In addition, various insect vectors spread the disease in the field. In infected plants the leaves are cupped downward and have a mottled appearance. Often the leaves appear thick and leathery. The base of each leaflet is usually attenuated. The general effect is reduced yield and delayed maturity. A breeding program now under way is designed to introduce mosaic resistance into the variety.

Powdery mildew, caused by the fungus *Erysiphe polygoni*, rarely occurs in the Sacramento and San Joaquin valleys. It may be important near the coast. Sulfur dusting offers an effective control.

Red spider and thrips may become severe on beans grown without irrigation. Under those conditions the plants can be dusted with flowers of sulfur. This precaution, however, must be taken before the spider population is large, because the sulfur is a repellent rather than a preventive.

SELECTION WORK IN THE RED KIDNEY VARIETY

Red Kidney beans, often called Western Red Kidney, have been studied in Yuba County for eight years. The first object was to purify the variety, and then make selections having valuable characteristics, such as earliness, uniformity, high yield, and conformity to type demanded by the market. In 1933 and 1934, test plots were made of several strains obtained from different sources. In the fall of 1934 new plant selections were made in different fields of Red Kidney. These were grown in 1935 in plant-to-row tests, which included 199 selections from Simpson's Strain, 97 from Geneva Red Kidney, and 101 from York Red Kidney. Every tenth row was planted with bulk seed from Simpson's Strain. Notes were taken on the progeny rows; inferior ones were discarded. The others were harvested; and on the basis of yield, size, color, and conformity of seed, some were chosen. In 1936 the selections were replicated three or four times in the plots. Tests were conducted on 34 selections of Simpson's Strain, 12 of Geneva Red Kidney, and 11 of York Red Kidney. In addition, 22 selections were tested from Dark Red Kidney, White Kidney, and some hybrids between Red Kidney and Nagazura, a Japanese variety with large red-mottled seed on a buff background. The crosses were made in connection with a study of in-

heritance of seed-coat color (*12*). In the breeding nursery at Berkeley some self-colored red segregates showed promise, having larger seed than the Red Kidney parent. In 1936 a number of them were planted in test plots at Marysville. The results showed that some of the selections had no merit in comparison with the commercial Red Kidney, and these were dropped. Next, 26 selections were tested in 1937, each being replicated six times. Only 1 of Geneva and 1 of York survived the competition. From the 199 plant selections made in 1934 from Simpson's Strain, only 12 remained. In addition 5 selections from Wells Red Kidney, 1 from Dark Red Kidney, 1 from Maui Red Kidney, 2 from White Kidney, and 3 hybrids involving Red Kidney were tested in 1937. Table 3 lists briefly the selections tested at Marysville, with their yield data.

Of the 26 selections tested in 1937, only 12 showed some merit. The seed not used in the yield-test plots was planted in increase plots, the purpose being to increase the worthy selections while the tests were being made; then, when one was finally chosen, there would be enough seed on hand to make a good start in its distribution. This propagation work was done by the grower on whose land the yield tests were conducted. The work required care in harvesting to prevent mixing. Each selection was harvested and stored separately; and when one was considered inferior, that lot was taken out, the tag destroyed, and the seed sold as commercial beans. Only 7 selections survived the competition in 1937 for the tests in 1938. Each was replicated eight times. The 7 included 1 Geneva Red Kidney, 2 Simpson's Strain, 2 hybrids, and 1 Maui. In that year Michigan Dark Red Kidney was added to the test, making 8 selections in all.

In 1938 other tests were made—one near the town of Clements and one on Union Island, both in San Joaquin County; the object was to determine the effect of diverse local conditions. Results were also obtained that year from the same selections tested by the New York Agricultural Experiment Station at Ithaca. Table 4 gives the data.

Judging from the data on the selection work summarized in tables 3 and 4, selection 7811 was the best. It had a consistently high yield record, together with larger seed than the commercial Red Kidney.

The other selections listed in tables 3 and 4 were discarded for various reasons. Red Kidney 7812, a large-seeded selection from the cross Nagazura × Red Kidney, was discarded because the beans were too large and flat. Maui Red Kidney 7815, a high-yielding selection of Dark Red Kidney obtained from Hawaii, was too late to be of value; and the seed coat was too dark for the Red Kidney variety as known commercially. Michigan Dark Red Kidney 8099, obtained from Michigan State College in 1938, will be discussed later. Simpson's Strain Selection 7803, one of

TABLE 4

SUMMARY OF RED KIDNEY PLOTS, 1938*

Accession no.	Marysville				Clements			Union Island			Total			Ithaca, New York	
	Number of plots	Index†	Pounds per acre	Yield rank	Number of plots	Pounds per acre	Yield rank	Number of plots	Pounds per acre	Yield rank	Number of plots	Pounds per acre	Yield rank	Pounds per acre	Yield rank
4989	8	47.1	2,320	5	5	2,030	7	5	2,558	3	18	2,306	6	1,346	2
7811	8	55.9	2,569	1	5	2,216	4	5	3,012	1	18	2,594	1	1,368	1
7799	8	48.1	2,545	2	5	2,136	6	5	2,794	2	18	2,501	2	1,169	7
7803	8	46.9	2,355	4	5	2,570	2	5	2,508	4	18	2,457	3	1,210	5
7795	8	47.5	2,178	7	5	2,582	1	5	2,496	5	18	2,378	4	1,274	4
7812	8	61.0	2,496	3	5	2,146	5	5	2,364	6	18	2,362	5	1,345	3
Check	8	49.7	2,270	6	5	2,278	3	5	1,924	7	18	2,176	7	1,204	6
Least difference for significance...	....		401	..	..	699	..	..	346	..	..	269	..	.....	

* Coöperating growers: Marysville, Otto Speckert; Clements, L. A. Rozzoni; Union Island, Sherid Moran; Ithaca, New York, Dr. E. V. Hardenburg.

† Index is the average weight of 100 beans in grams.

the better selections, nevertheless gave way in competition to 7811, which was earlier, yielded more, and had larger seed. Geneva Red Kidney 7795 was considered the best selection in that variety. It was dropped in 1938 because other selections from Simpson's Strain and certain hybrids appeared to be superior to it. Simpson's Strain Selection 7799, despite a very good record, was retired in preference to 7811, which had equal yield and larger seed. York Red Kidney 7796 fell out of competition in 1937. Wells Red Kidney 4989 never obtained the uniformity or productive ability of 7811 and was therefore discarded.

Fig. 4.—Field of the variety Red Kidney 7811, Marysville, 1940.

Characteristics of the Selection Red Kidney 7811.—Red Kidney 7811 was a hybrid, Nagazura × Red Kidney, which had been back-crossed to Red Kidney. It has two characteristics from the Nagazura parent: large seed and red-blotched pod. The blotching is evanescent, not showing until the pods are ripe and disappearing in a few days after the pods are hard. It is a good varietal distinguishing characteristic in the field. The selection is more uniform in size and does not have so many long, drooping, easily broken basal branches as the commercial Red Kidney. It is slightly earlier and more uniform in maturity. Its high-yielding capacity has been shown in several areas of California and it has also given high-yield records in New York State, as indicated in tables 3 and 4.

History of the Selection Red Kidney 7811.—The rapid rise of Red Kidney 7811 from a single seed to an important variety is shown by the following historical account. In 1931 a plant, with mottled seed, from the cross Nagazura × Red Kidney was crossed with Red Kidney. Five seeds developed in the pod. The cross was given the number 31.078. The

five seeds were planted the following year in row 35(120)32, and five F_1 plants were grown. The second plant was grown in 1933 in row 39(149)33, and the F_2 population consisted of 20 mottled and 19 self-colored plants. Only 3 were saved. One of the plants saved from this row was planted in 1934 in an F_3 progeny row 209(328)34 and bred true for red, from which 59 plants were harvested in bulk. In 1935 the seed was not used, but in 1936 it served to plant four replications in yield tests at Marysville. After the tests the promising selections were given accession numbers; this selection has been known, ever since, as 7811. In

TABLE 5

PRODUCTION OF THE SELECTION OF RED KIDNEY 7811, 1937–1941

Year	Production in bags in the counties given*			Total bags	Per cent of the certified Red Kidney production
	Yuba	Sutter	San Joaquin		
1937	5	...	....	5	0.08
1938	120	...	....	120	0.06
1939	976	...	....	976	13.21
1940	2,731	783	....	3,514	25.70
1941	6,807	667	7,157	14,631	60.67
1942 (expected)	.....	...	....	....	100.00

* Bags of 100 pounds.

1937 there were six replications of the selection in the plots. The seed not used in the plots was increased, and 498 pounds was harvested. From the five bags the variety began to spread (table 5). By 1941 over 60 per cent of the beans grown for Calapproval was increase from the cross made ten years earlier. The table takes into consideration only the beans that traced directly back to the original source. This selection has been grown by several California farmers who did not take the trouble of preserving its identity. In addition, shipments have been made to New York since 1939: about 2,400 bags or 4 carloads of this selection were sold there in 1940 (fig. 4); and in 1941 a large proportion of the seed shipped east was Red Kidney 7811. In 1942 this will be the only variety approved for pure seed; and although the old variety will linger, the new one will probably largely replace it soon even in fields devoted to dry beans. The variety has been readily accepted in New York, where its yields have also been superior (table 4).

OTHER KIDNEY BEAN VARIETIES

Michigan Dark Red Kidney.—Dark Red Kidney, also known as Mahogany Red, is grown largely in Michigan. Collins and his associates (*7*) presented production figures on Red Kidneys there for 1929–1938

inclusive; the annual production varied from 50 to 182 thousand bags, with an average of 118 thousand, comprising 62 per cent of the total Red Kidney crop in that state.

In California the variety has not been important, although canners are beginning to appreciate its qualities as a salad bean. In 1938 it was subjected to yield and cooking tests to see whether locally grown beans could be supplied to California canners, who usually import the variety

TABLE 6

Comparative Yields of Michigan Dark Red Kidney and Red Kidney 7811 in Pounds per Acre, 1938–1941*

Variety	Accession no.	Marysville				Clements		Sutter Basin
		1938	1939	1940	1941	1939	1940	1940
Red Kidney	7811	2,569	1,880	2,202	2,420	2,836	2,360	2,117
Michigan Dark Red Kidney	8099	2,331	1,929	1,404†	2,247	2,706	2,279	1,899†
Per cent yield of Michigan Dark Red Kidney based on Red Kidney	....	87	103	64	93	95	97	90

* Coöperating growers: Marysville, Otto Speckert; Clements, L. A. Rozzoni; Sutter Basin, W. J. Duffy, Jr.
† Significant differences.

from Michigan. Another market outlet could be developed by supplying disease-free seed for Michigan growers.

Table 6 summarizes the yield-test results. On the average the yield has been 90 per cent of that of Red Kidney 7811. The variety has been grown experimentally in several places in the state. The beans harvested, identified only by numbers, were submitted to the canners for testing. The results indicated that beans from Vina, Marysville, Sutter Basin, Stockton, and Hollister were usually acceptable. Samples from Davis and Berkeley were not uniform, and those from southern California failed to meet the canners' requirements.

A small increase of seed from Michigan Dark Red Kidney was made at Marysville in 1939. Most of the 40 bags were sold in the East. In 1940 another small increase was made on the University Farm at Davis for foundation seed, and in 1941 this was grown commercially in three counties. The total production was 766 bags, distributed as follows: Yuba County, 448; Sutter, 168; San Joaquin, 150. Much of the 1941 crop was readily sold to the canners.

Some canners independently shipped in Dark Red Kidney beans to supply their growers. The results were somewhat discouraging because the seed thus purchased contained a mixture of hybrids and other off-

type beans, which on cooking did not retain the desired rich dark-red color; these off-color types are called "faders." Calapproved seed is free from this difficulty and also from thresher injury, which causes cracked beans. Canners will therefore do well to require Calapproved seed.

White Kidney.—To complete the discussion of kidney beans as a type, mention is made here of the variety White Kidney. Preliminary tests have been made on 167 single-plant selections made in a field of this variety in 1939. The use of this variety will probably be limited to a relatively small acreage devoted to disease-free seed production for eastern growers. For this purpose, superior strains are expected to be isolated from the present variety.

SUMMARY

Red Kidney bean production in California is discussed, special emphasis being placed on improvement of types. Except for brief mention of two relatively minor varieties, Michigan Dark Red Kidney and White Kidney, the main emphasis is on the major variety known as Red or Western Red Kidney.

California produces only about 12 per cent of the national total for the Red Kidney variety; the influence on the industry, however, is far greater than this production would indicate, because California furnishes seed for New York, the nation's greatest Red Kidney producing state.

The production of Red Kidney beans in California is restricted largely to the river-bottom soils of the Sacramento and San Joaquin valleys. These and other areas are discussed.

The growing of seed beans is discussed at some length; but most of the findings that apply to good seed production can be utilized by growers of market beans.

Cultural methods common in the growing of Red Kidney beans are described. Emphasis is upon seed injury during threshing and recleaning and upon its importance in seed production. The vulnerability of the bean embryo to injury is shown in words and pictures. Since causes of injury have been found and preventives devised for mechanical injury in threshing, this operation is given considerable emphasis.

Experiments are described through which was isolated a superior strain known as Red Kidney 7811. Its pedigree, yield, and rise to dominance in California are given in detail.

LITERATURE CITED

1. Bainer, Roy, and H. A. Borthwick.
1934. Thresher and other mechanical injury to seed beans of the lima type. California Agr. Exp. Sta. Bul. 580:1–30.

2. Bainer, Roy, and J. S. Winters.
1937. New principle in threshing lima bean seed. Agr. Engin. 18(5):205–6.

3. Bainer, Roy, and J. S. Winters.
1938. Results of tests of a rubber roller seed bean thresher. Agr. Engin. 19(6): 251–52.

4. Borthwick, H. A.
1932. Thresher injury a cause of baldhead in beans. Jour. Agr. Res. 44:503–10.

5. Burkholder, W. H.
1930. The bacterial diseases of the bean. A comparative study. New York (Cornell) Agr. Exp. Sta. Mem. 127:1–88.

6. California Coöperative Crop Reporting Service.
1940. Dry edible bean production by varieties for California and for other leading states. California State Dept. Agr. Coöp. Crop Reporting Service. 1 p. (Mimeo.)

7. Collins, M. D., D. M. Holmberg, J. B. Schneider, and G. B. Alcorn.
1939. Red Kidney beans. California Agr. Ext. Service. 14 p. (Mimeo.)

8. Hedrick, U. P., W. T. Tapley, G. P. Van Eseltine, and W. D. Enzie.
1931. Vegetables of New York. Vol. 1, Part II. Beans of New York. New York State (Geneva) Agr. Exp. Sta. 110 p.

9. Hendry, G. W.
1918. Bean culture in California. California Agr. Exp Sta. Bul. 294:1–70. Revised June, 1921.

10. Gloyer, W. O.
1928. Two new varieties of Red Kidney bean: Geneva and York. New York State (Geneva) Agr. Exp. Sta. Tech. Bul. 145:1–51.

11. Scott, G. A., and L. M. Clark.
1941. Bean production by varieties for California and for other leading states. California State Dept. Agr. Coöp. Crop Reporting Service. 1 p. (Mimeo.)

12. Smith, Francis L.
1939. A genetic analysis of red seed-coat color in *Phascolus vulgaris*. Hilgardia 12(9):551–621.

13. United States Department of Agriculture.
1941. Agricultural statistics, 1941. 731 p. U. S. Dept. Agr.

14. Wellman, H. R., and E. W. Braun.
1927. Beans (Series on California Crops and Prices). California Agr. Exp. Sta. Bul. 444:1–62.

15. Young, H. N.
1931. Production and marketing of field beans in New York. New York (Cornell) Agr. Exp. Sta. Bul. 532:1–203.

15m-8,'42(2108)